

THE HISTORY AND CONSTRUCTION OF THE WASHINGTON MONUMENT



A thesis prepared as a requirement for initiation into

TAU BETA PI

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by

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SUMMARY

In 1833 a body of influential citizens of the City of Washington determined to redeem the oft-repeated failure of Congress and to undertake the erection of a national monument in memory of the first President of our country. Accordingly, the Washington National Monument Society, a voluntary organization, was formed for the purpose of "erecting a great national monument to the memory of George Washington at the seat of the Federal Government". Chief Justice John Marshall was chosen as President and at his death in 1835, he was succeeded by ex-President James Madison. In 1836 steps were taken to inaugurate a national campaign to secure contributions and American artists were invited to enter into competition with one another and submit designs for the monument. The design of Robert Mills, a well-known architect of the time, was selected, but the present monument has little in common with Mills' original elaborate plan.

Having, by 1848, accumulated sufficient funds from public canvassing to commence work, Congress was petitioned by the Society for permission to build. Congress authorized the Society to erect the monument and designated the President of the United States and the Board of Managers of the Society to select a suitable site. In 1783, the Continental Congress had authorized an equestrian statue of General Washington to be erected at the seat of Congress. The site for this statue, provided in the L'Enfant Plan of 1791, was at the intersection of the meridian line

through the Executive Mansion and the east-west line through the dome of the Capitol. Due to the marshy condition of the ground at this location the site was moved a few hundred feet to the southeast.

The cornerstone was laid in 1848 and work progressed steadily, though slowly, until 1855. During the last few years of this period funds had run to a low ebb and contributions of all natures were being solicited and encouraged. Memorial stones were being sent from States, cities, and societies in this country and also from foreign nations to be used in the monument's construction. Congress had been petitioned for aid but without result. In 1854, an act occurred which so outraged and angered the public that all manner of public support soon ceased, and with it construction on the monument. A stone, sent by the Pope at Rome, was stolen and never recovered. The shaft, at this time, had obtained a height of 152 feet above the floor.

Work was resumed in 1859 when the Society was incorporated by an Act of Congress for the purpose of completing the erection of the monument. An officer of the Engineer Corps was detailed as a superintendent of construction and the endeavor was again made to raise funds by means of public appeals. The advent of the Civil War a few years later again interfered with public interest in the work and the shaft was forced to remain as when abandoned back in 1855. In 1872 Congress became interested in the lack of progress in the construction of the monu-

ment and at last, in 1876, approved an Act providing that the government assume the responsibility of the monument's completion. The Act provided that \$ 200,000 be appropriated and supplementary appropriations be made annually until the erection was finished. The task was placed in the hands of the Corps of Military Engineers and, after many difficulties, completed in December, 1884.

SUMMARY OF STATISTICS CONCERNING THE WASHINGTON
MONUMENT

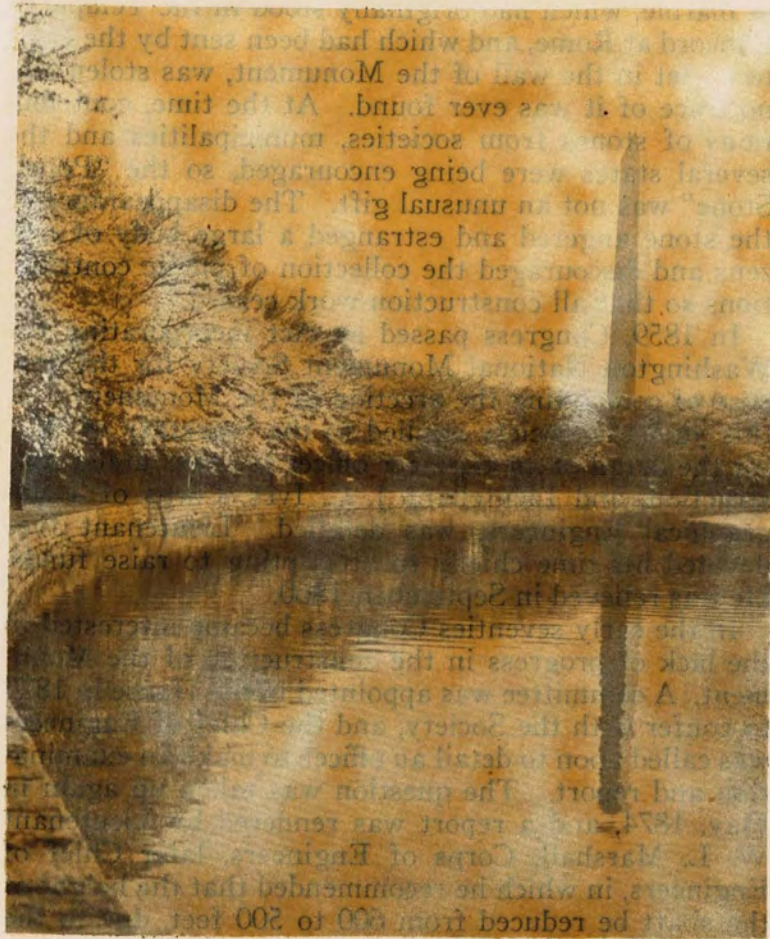
Corner-stone laid	July 4, 1848
Capstone set	December 6, 1884
Dedicated	February 21, 1885
Opened to public	October 9, 1888
Total cost	\$1,300,000 (approx.)
Height above floor	555 feet, 5.125 inches
Height of shaft	500 feet, 5.125 inches
Side of base of shaft	55 feet, 1½ inches
Side of top of shaft	34 feet, 5½ inches
Taper of walls of shaft	0.247 inch to 1 ft.
Thickness of walls base of shaft	15 feet
Thickness of walls top of shaft	18 inches
Thickness covering slabs, pyramidion .	7 inches
Material used on face of shaft	White marble
Depth of foundation	36 feet, 10 inches
Area foundation (126 ft. 6 in. sq.) ..	16,002 square feet
Weight - foundations	36,912 tons
Weight - shaft and pyramidion	63,933 tons
Weight - Monument	81,120 tons
Max. pressure on underlying soil	9 tons/ sq. ft.
Pressure on edges of foundation	3 tons/ sq. ft.
Windows:	
Number	8
Height above ground	504 feet
Dimension (except east window)	18 inches x 3 feet
Dimension - east window	2 feet x 3 feet
Memorial stones (1932)	187
Elevator	Electric

THE HISTORY AND CONSTRUCTION OF THE WASHINGTON MONUMENT



"Taken by itself, the Washington Monument stands not only as one of the most stupendous works of man, but also as one of the most beautiful of all human creations. Indeed, it is at once so great and so simple that it seems to be almost a work of nature."

INTRODUCTION TO THE WASHINGTON MONUMENT



The Washington Monument as Seen Across the
Tidal Basin

The Washington National Monument has a history which is almost as old as that of our country, and the names of some of our greatest statesmen are connected with it. However, notwithstanding all its influential backing and support, almost every imaginable obstacle had to be overcome, including the securing of Congressional action, the raising of money by house-to-house canvass, the disproving of charges of corruption, the wading through a religious controversy and the solving of momentous engineering problems before the monument was finally completed and allowed to take its rightful place as one of the eight wonders of the world.

On August 7, 1783, at the close of the Revolutionary War, the Continental Congress unanimously resolved (ten states being present) :-

"That an equestrian statue of General Washington be erected at the place where the residence of Congress shall be established in honor of George Washington, the illustrious Commander-in-chief of the Armies of ~~the~~ United States of America during the war which vindicated and secured their liberty, sovereignty, and independence."

In accordance with this resolution and under the immediate direction and subsequent approval of President Washington, L'Enfant, in 1791, provided a location for this statue in his plan for the City of Washington. This site was also the site later selected for the monument to the heroes of the Revolution, which was proposed in 1795.

At Washington's death a joint committee of both Houses of Congress was appointed to consider a suitable manner of paying honor to his memory. On December 24, 1799, Congress passed a resolution, on the motion of John Marshall, which provided:-

"That a marble monument be erected by the United States at the city of Washington, and that the family of General Washington be requested to permit his body to be deposited under it, and that the monument be so designed as to commemorate the great events of his military and political life."

Although Mrs. Washington acceded to this request at the expense of her own personal desires as to the final resting place of her husband, the resolution was not executed.

The matter was brought up again in 1816 and later in 1819 but no definite agreement was reached. At this time plans were under foot to recover Washington's body from Mount Vernon and to place it beneath the floor of the crypt under the dome of the capitol in a vault prepared solely for that purpose. This proposal was brought to the attention of Congress in 1824 by the President and later in 1825 by John Quincy Adams, but still no action was taken. Even had Congress taken definite steps to put the last plan into effect it is extremely doubtful that it would have been successful for tentative approaches made in its behalf to the surviving members of Washington's family met with stern disapproval. They refused to grant permission to exhume General Washington's body.

On the eighth of May, 1800, a select committee of the House of Representatives submitted resolutions

directing that the resolution of Congress of 1783 and that of 1799 be executed. That part referring to the resolution of 1783 was amended to require a mausoleum for George Washington to be erected instead, and for this purpose, later, a bill passed the House of Representatives, January 1, 1801, appropriating \$200,000 but this time the Senate did not concur.

Finally, in 1833, the first definite and concrete steps taken in the behalf of a Washington memorial were made by a group of private citizens of Washington who were determined to persevere until their dreams were realized and the Washington Monument an actuality. Through their efforts, a society was formed and known as the Washington National Monument Society. Though their enthusiasm was high, the Society realized early that they were faced with many serious problems. They had no money with which to begin the construction of the monument; they had no site on which to build the monument; they hadn't even a single plan for the monument they so fervently wished to construct. Under the leadership of Chief Justice John Marshall and, after his death, ex-President James Madison, steps were taken immediately to inaugurate a national campaign to secure contributions. Contributions were at first limited to not more than one dollar from any individual and societies were not allowed to contribute as a group. However, in a short while appeals were being sent around for contributions of any nature and of any amount.

A type of appeal sent to the many Masonic Lodges is as follows:-

"Worshipful Brother:

An appeal in the name and memory of Washington is made to our Order for aid toward the completion of the Monument to his Fame. The object requires no words of commendation to Masons, for Washington was Chief among them. About 3000 of the more prosperous Lodges will be appealed to, and a majority of them will, doubtless, respond. The sum of \$100.00 is solicited of each, thus entitling them to record in the archives of the Society.

N.B. All contributions should be sent to John C. Brent, Secretary of the Society, Wash., D.C.

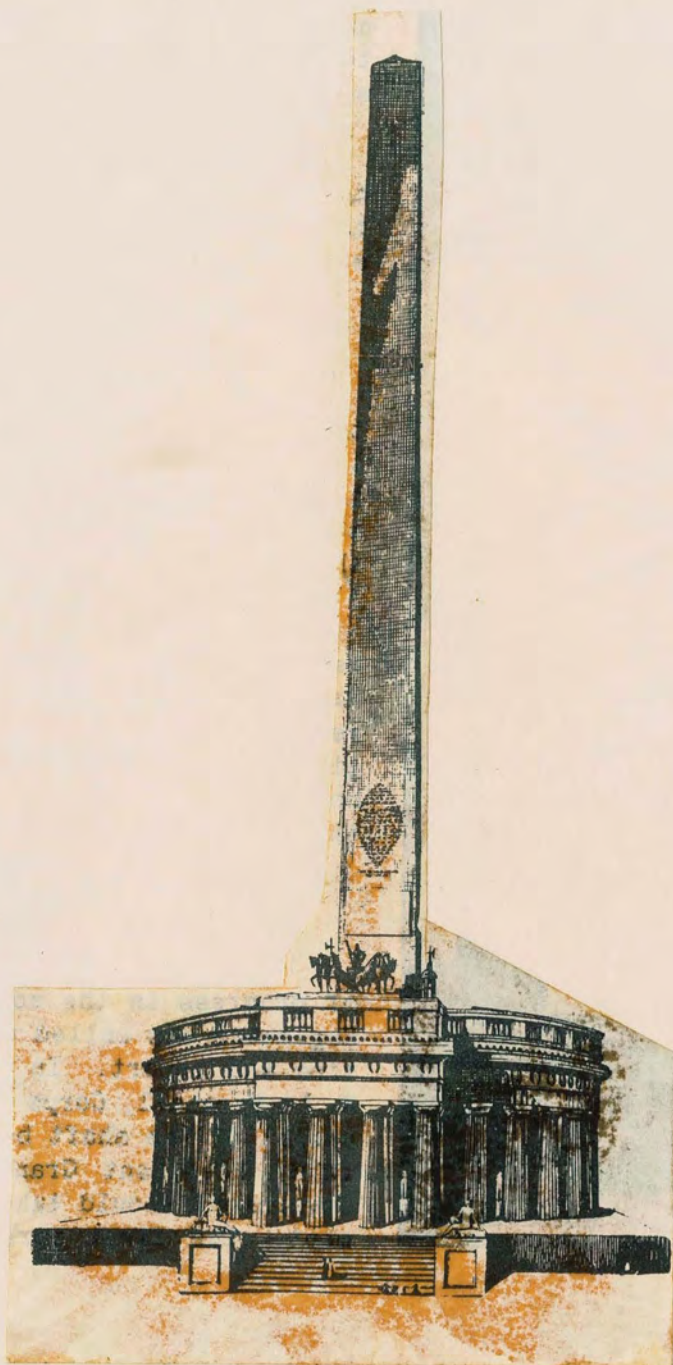
Fraternally,

Jno. S. Benson

The Society next, in 1836, invited designs to be submitted by American artists for a monument to cost approximately \$1,000,000.00. The competition was won by a well-known architect of the time, Robert Mills. By 1848 the Society felt that it had sufficient funds with which to commence building and so they petitioned Congress for permission to erect a fitting monument to perpetuate the fame and memory of George Washington. In January of the same year, Congress granted them the requested permission and appointed a group comprised of the President of the United States and the Board of Managers of the Society to select the site for the proposed monument. The site provided in the original map of the city by L'Enfant for the equestrian statue of Washington and

later for the statue to the heroes of the Revolution was finally hit upon. On July 4, 1848, the corner stone was laid amid great ceremonies. The Society had, by this time, raised through contributions approximately \$88,000. Actual work on the monument had at last begun.

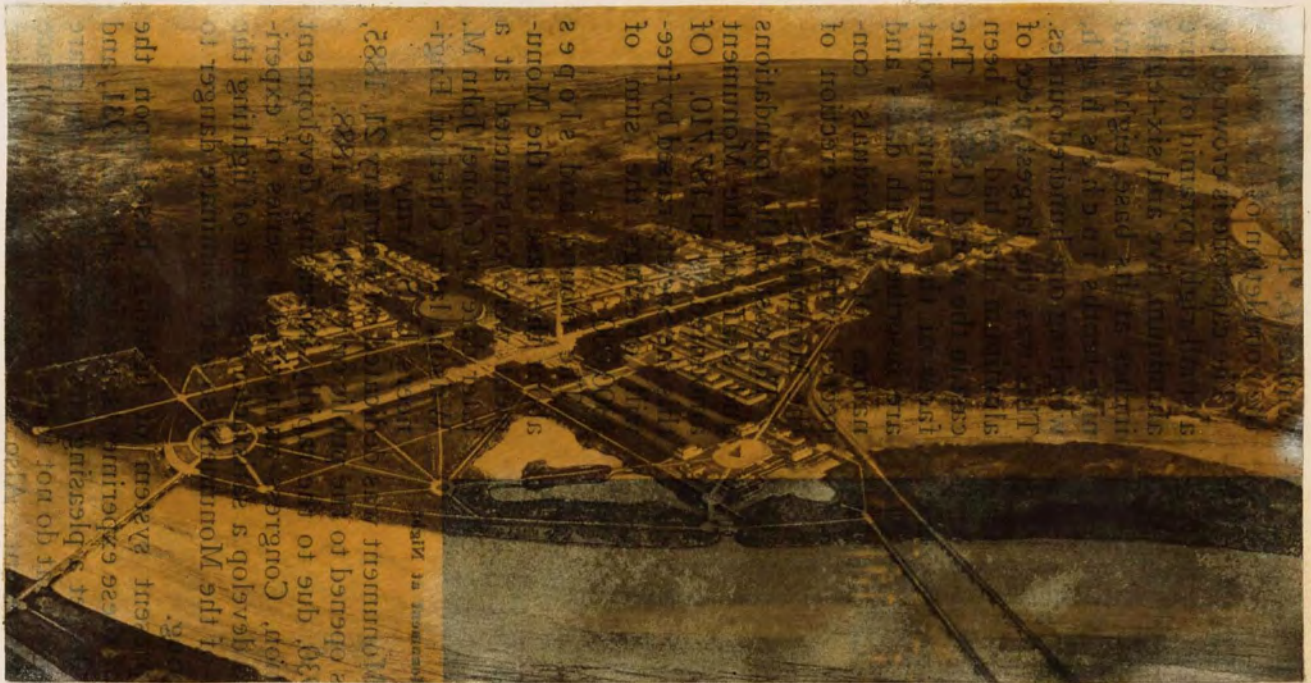
DESIGN OF THE WASHINGTON MONUMENT



The original design of the monument submitted by
Robert Mills.

The Washington Monument, as we know it today, has little in common with the design of its originator, Robert Mills. Mills' elaborate plan was comprised of a vast stylobate, surmounted by a tetrastyle pantheon, circular in form, and with an obelisk 600 feet high rising from the center. The original design called for the entire height of the shaft to be Egyptian decorated and to be of 700 feet. This 700 feet was to be mounted on the conic Babylonian base and the whole surrounded by the circular Greek temple. This temple was to be 100 feet high and 250 feet in diameter. It was to act as an American pantheon, a repository for statues of Presidents and national heroes. Above the east doorway there was to be a 30 foot figure of General Washington, clad in a Roman toga, sitting in a Greek chariot drawn by Arabian steeds driven by an Etruscan winged Victory. Fortunately, the type of base and the pantheonic features of this design were never adopted. The beauty of the Washington Monument lies in its simplicity and regal strength - emblematic of the character of the man to whose memory it is dedicated. All of the designs submitted during the competition had the obelisk or shaft in common suggesting that the Society must have requested just such a feature be included in all designs.

SITE OF THE WASHINGTON MONUMENT



General Plan for the Development of the Central Axis
of the Mall, Wash., D.C.

The L'Enfant plan for the city of Washington was followed in so far as the street plan, the location of the Capitol building and the White House were concerned, but other plans for the grouping of government buildings has been neglected.

The site for the equestrian statue of Washington provided in the L'Enfant plan was at the intersection of the meridian line through the Executive Mansion and the east and west line through the dome of the Capitol. However, the Mall had not, as yet, been developed as proposed and planned by L'Enfant and in 1848 this location was still marsh land and so the site was moved to a higher level a few hundred feet from the intersection. The Monument stands close to the intersection of the Jeffersonian meridian line of 1802, passing through the center of the Executive Mansion, north and south, with a line running due east and west through the center of the Capitol building. It is located adjacent to the Potomac River, on a government plot comprising $78\frac{1}{2}$ acres and being public property. The grounds around the monument have been kept clear of any other buildings and, consequently, the view of the entire shaft will never be obstructed. The elevation of the ground on which the monument stands is 26 feet above low tide-water in the Potomac River.

CONSTRUCTION OF THE WASHINGTON MONUMENT

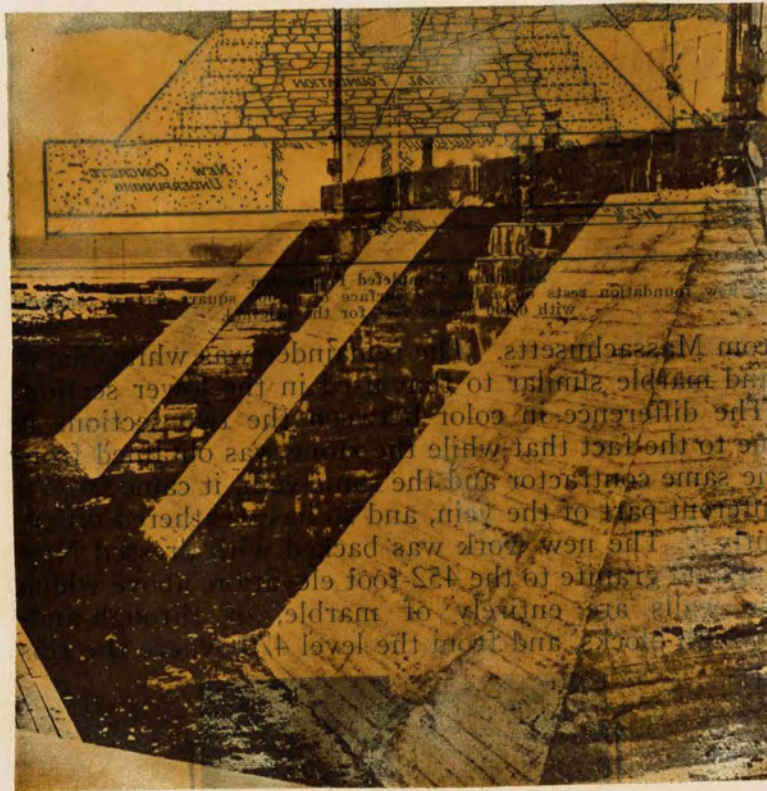
THE FOUNDATION



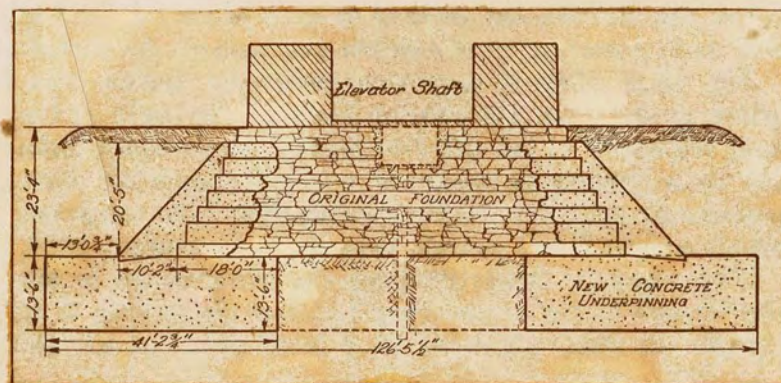
Original Rubble-Stone Foundation



Removing old Rubble for Underpinning



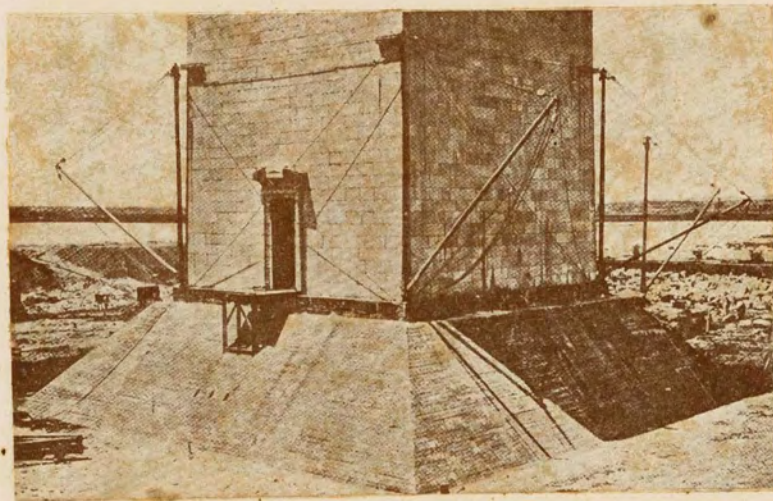
Underpinning Half-completed



Section of Completed Foundation



The Monument in 1879



Underpinning Completed.

June 7, 1880.

In 1859, after it had passed an Act incorporating the Washington National Monument Society, Congress complied with the request of the Society and detailed an engineering officer to supervise the construction of the monument. The officer was Lieutenant J. C. Ives, Corps of Topographical Engineers. Lieutenant Ives, though, devoted his time chiefly to attempting to raise funds for the monument's completion and was relieved in September, 1860. In the early seventies Congress really became interested in the progress of the monument and detailed another of the engineers to make an examination and render a report to an appointed committee from the House and the Society. In May, 1874, Lieutenant W. L. Marshall, Corps of Engineers, later Chief of Engineers, submitted a report in which he recommended that the height of the shaft be reduced from 600 feet to 500 feet, due to the fact that the area covered by the foundation was insufficient to carry the load without causing excessive pressures on the soil.

When, in August, 1876, an Act passed putting the completion of the monument into the hands of the government, President Grant commissioned a board of officers from the Engineering Corps to investigate and report on the sufficiency of the foundation as it then existed. This board, under the direction of Lt. Col. Thomas L. Casey, reported that the foundations were inadequate. Acting on the report the first work under-

taken was the underpinning of the present foundation.

The strata were found to be very compact and, at a depth of 20 feet, a solid bed of gravel 6 feet deep was encountered. The original foundation was of blue gneiss rock, in large blocks, as they came from the quarry, laid in lime mortar with a small portion of cement. It was 80 feet square at the base, covering an area of 6,400 square feet, pyramidal in shape, having offsets or steps and extended 7 feet 8 inches below ground and 15 feet 8 inches above ground. The blocks weighed from 6 to 8 tons. The mortar used was made of hydraulic cement, stone, lime and sand. The base of the monument is 55 feet $1\frac{1}{2}$ inches square, and the walls at this point are 15 feet thick. The present foundation is 126 feet 6 inches square, covering an area of 16,002 square feet. It is 36 feet 10 inches in depth and extends down to a level 6 inches below the permanent level of water in the site on which the monument is located.

When work was undertaken by Lt. Casey, he first decided to enlarge the old foundations by building a new concrete sub-foundation in under the old and to distribute the weight of the shaft on the new foundation by a system of underpinning. This work consisted in digging away 70% of the earth under the old foundation to a depth of 13 feet 6 inches beneath it, and replacing this earth with a mass of concrete extending 18 feet within the outer edges of the old foundation and 23 feet 3 inches without the same

line. This was done by making two cuts on opposite sides of the monument, uncovering 144 square feet of bearing surface from beneath the old foundation. But this gave such a rapid settlement to the structure that after pouring the concrete in these first cuts, only one cut, exposing 72 square feet of bearing surface, was undertaken at one time.

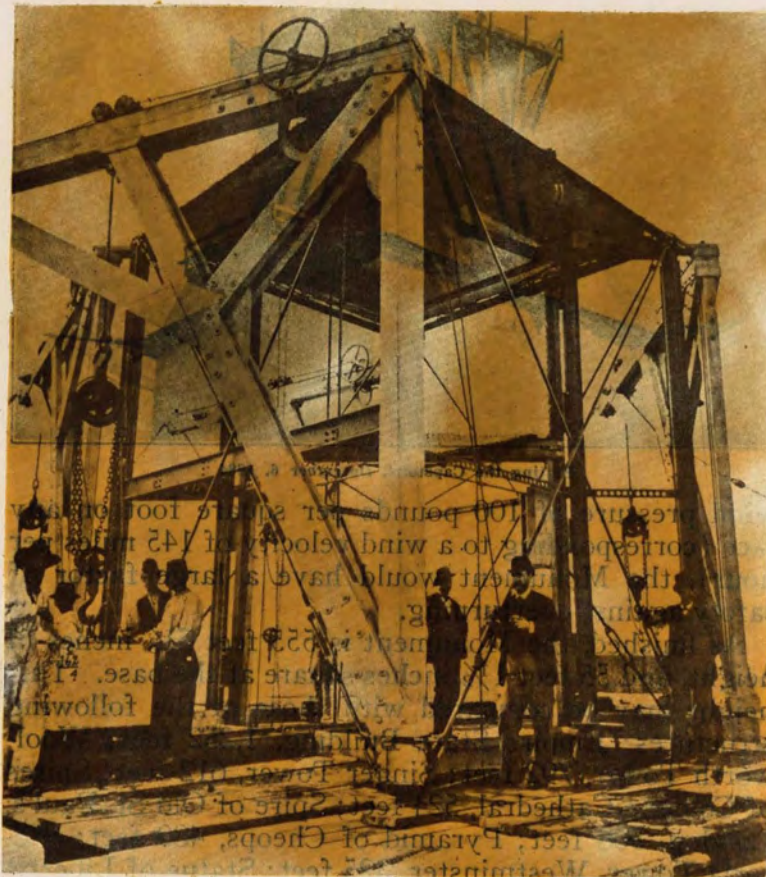
To distribute the pressure of the shaft over this new foundation the old rubble stone base was torn from under the walls of the shaft and replaced by a concrete underpinning extending out on to the new concrete slab. In the construction of this continuous buttress 51% of the cubical contents of the old foundation was removed and 48% of the area of the shaft undermined. The material employed in this work was Portland cement - mixture of one part cement, 2 parts sand, 3 parts pebbles, and 4 parts broken stone. This second step corrected a slight leaning of the shaft to the northwest caused by a variance in the settling of the corners.

The new foundation rests on a thick wedge of sand and gravel, varying from 10 feet to 30 feet in thickness. Under it lies a thick wedge of blue clay varying from 50 feet to 30 feet, all of which rests on bed rock at a distance of 60 feet below the bottom of the foundation. Bed rock is on a slight slope to the west.

This entire job was done without causing the slightest crack or the least opening in any part of the

monument already constructed. At that time, including the base, the monument stood at 180 feet in height. An 8 inch block, moulded on June 25, 1879, and tested on October 17, 1879, showed first crack at pressure of 105,000 pounds; the maximum pressure fracturing it was 122,000 pounds, or 1,906.25 pounds per square inch. It must be acknowledged that this was an engineering feat in itself.

CONSTRUCTION OF THE SHAFT OF THE WASHINGTON MONUMENT



Stone Setting Machinery

View of the Phoenix-column framework, 324-foot elevation, with cranes attached to outer columns. The Phoenix-columns support the elevator and the stairway in the completed monument. Oct. 1, 1880.

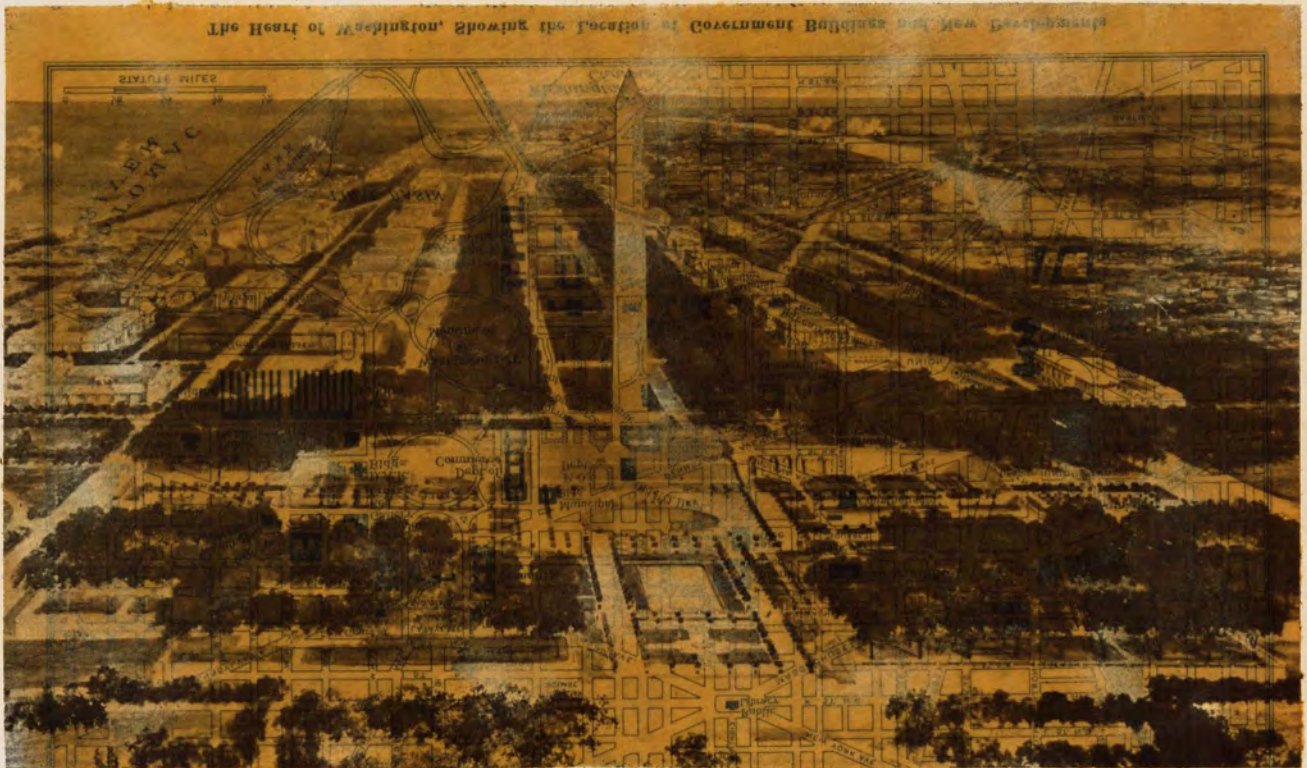
At the time the government took over the construction of the monument George P. Marsh, U. S. Minister to Italy, began his research on the traditional proportions of obelisks. His report showed:-

"A naked shaft, with or without inscriptions, the height of which is ten times the width of its base, faces of shaft slightly convexed. The dimensions of the shaft should be reduced as it rises, the top of the shaft varying from two-thirds to three-quarters of the linear measurement of the base.

A pyramidion or apex, the base of which is the same dimension as the summit of the shaft and unites with it directly without any ledge, molding, etc. The height of the pyramidion should be equal to the length of a side of the base of the shaft, and is, therefore, greater than the side of its own base."

This showed that Mills' proportions were at variance with these formalized dimensions and, when the work on the shaft was resumed in 1880 Marsh's studies were used to make the monument conform. It was impossible, however, to make the faces convex as they had been started as planes. Still, it is remarkable that, with the building partially constructed, the engineers were able to alter the proportions and yet retain the architectural unity of the structure. The proposed height was reduced to 555 feet 5 and one-eighth inches or 10 times the base line. The squat cap of Mills' plan was replaced by a steeply inclined pyramidion of acceptable design. If the shaft had been permitted to come to a point the point would have been reached at a height 2 and two-thirds times its present altitude.

WALLS - INTERIOR AND EXTERIOR - OF THE WASHINGTON
MONUMENT

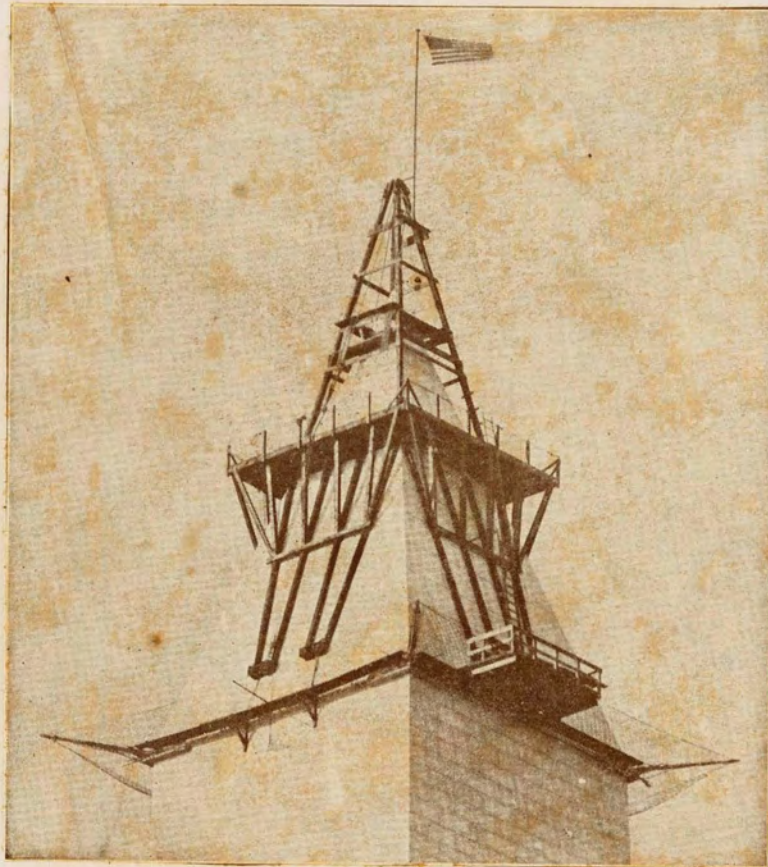


Development of the Mall and Washington Monument Grounds
as Proposed in 1901.

The exterior blocks of marble are laid in 2 foot courses of regular ashlar, or squared stone, backed by rubble masonry, up to the 150 foot level where the government engineers began their work. They substituted for the rubble backing a solid wall of New England granite, which is carried to the 452 foot level where through-and-through blocks of marble begin. This marble is fine grained and durable and weighs $178\frac{1}{2}$ pounds to the cubic foot. The first thirteen courses that the engineers laid, 26 feet, were faced with white marble that came from quarries in Massachusetts. They used this marble because they were unable for a time to obtain the Maryland marble used at the start. The new Maryland marble with which the remainder of the monument is faced, although from the same vein as the original stone used for the lower portion, is from a slightly different section of that vein and has weathered to a slightly different tone. This explains the "ring" or "high-water mark" sometimes noticed on the shaft of the monument.

The masonry constructed by the government is the best that is known to the engineering art, and the weight is so well distributed that even if subjected to a wind pressure of 100 pounds per square foot on any face - corresponding to a wind velocity of 145 miles per hour - the monument would have a large factor of safety against overturning.

THE PYRAMIDION OF THE WASHINGTON MONUMENT



Setting the Capstone, Dec. 6, 1884.

The pyramidion is of marble, 55 feet in vertical height; of 262 separate pieces of stone, containing 3,764 cubic feet of dressed stock. The covering slabs are but 7 inches in thickness and rest upon projections or spurs upon the marble ribs. These ribs are 12 in number, three on each side of the well, springing from the interior face of the walls at the height of 470 feet. They are then carried upward until the ribs nearest the angles of the shaft meet in the hips of the pyramidion, while those in the center of each face are connected still higher up by voussoir stones, forming two arches intersecting each other at right angles. The trust of a corner rib is transmitted to its opposite by the use of horizontal stones between their upper extremities. The keystone of the center ribs is at a height of 529 feet.

The cap-stone weighed 3,300 pounds and was crowned by a small right pyramid of pure aluminum 5.6 inches at its base and 8.9 inches high, weighing 100 ounces and being the largest piece of this metal ever cast anywhere up to that time. The aluminum is surrounded by 144 platinum tipped lightning conductors. It is inscribed on all four sides - north, the names of the members of the commission which completed the construction; west, important dates in the history of the monument itself; south, the names of the technical staff; and east, the phrase, "Laus Deo", meaning,

"Praise to God". The entire weight of the pyramidion
is 300 tons.

THE ASCENT - STAIRWAY AND ELEVATOR - TO THE TOP OF
THE WASHINGTON MONUMENT



The Washington Monument as seen from
Arlington, Va.

The ascent to the top of the monument may be made either by means of an iron stairway or by means of an elevator. The elevator is supported by a construction of eight vertical Phoenix iron columns - four $6\frac{1}{2}$ and four $5\frac{1}{4}$ inches internal diameter - I beams, channels and ties. The four columns terminate at the height of 500 feet and four within the roof at 517 feet. These latter four sustain the elevator machinery above. The eight columns are arranged in concentric squares. The elevator was originally steam but is now electrically powered. The first elevator, or steam hoist, was used only until 1900, when the first electric elevator, requiring five minutes for the ascent, was installed. This latter was condemned in 1922 and replaced in 1927 by the new electric elevator which now makes the ascent in $1\frac{1}{4}$ minutes operating on a five minute schedule. The elevator is hoisted by steel cables around 2 inches thick. There is room for thirty people in the elevator and its capacity is 10 tons, with a safety factor of 15.

The stairway consists of alternate, short flights strung along the north and south sides of the wall, connecting with platforms 4 feet 8 inches wide to a height of 150 feet and 7 feet 10 and three-fourths inches wide. The flights extend along the east and west walls there being 50 flights and 898 steps.

The rating of the electric dynamo used in running the elevator is as follows:-

50 kw. - 250 volts.

Engine - double worm

Speed of elevator - 100 feet per minute

Engine governor throws off current at 105
feet per minute.

Car safety stops car at 150 feet/min. speed

Elevator is tested at 6 tons.

Capacity 10 tons?

*disagrees with
1 1/4 minutes.
(see previous
page)*

INTERESTING DETAILS AND ROMANTIC FEATURES OF THE
WASHINGTON MONUMENT



The Washington Monument taken with Telephone ^{to} Lens
from the Slopes of Arlington, Va.

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On the night of February 21, 1855, the Washington Monument was "stolen". A new anti-foreign, anti-Catholic political organization called the American Party and known as the "Know Nothings", broke into the offices of the Washington National Monument Society and seized its records and books. They then held an "election" to oust the former owners and voted their own members into office. After two years the party fell into disrepute and collapsed. The monument was then returned to the official society.

It was this same group that is believed to have been the cause of the disappearance of the "Pope's Stone". When the Society was waging its last efforts towards the completion of the monument blocks of marble were being received from all parts of the country and from some foreign nations. All the states in the country sent a block of stone, and also many cities and societies, to be set in the interior. ^{Blocks were} A block was sent from the Free States of Bremen, Japan, China, Turkey, and Greece. The block sent by Turkey was of white marble, highly polished, and very ornamental. It is interesting to note that the block sent by Greece was a white marble taken from the ruins of the Parthenon. One of the stones sent was a block of African marble taken from the Temple of Concord at Rome, and was the gift of Pope Pius IX. It bore the inscription, "Rome to America". The American, or "Know Nothing", Party protested this "Papist" gift and, when their com-

plaints were disregarded, they resorted to violence. At night, March 5, 1854, a band of masked men overpowered the night watchman at the monument, broke into the lapidarium where the memorial blocks were kept, and stole the disputed block of marble. It is believed they then smashed and threw it into the Potomac River. At any rate, although a reward was offered for its return, it was never recovered. This act caused the work of the Society to come to an abrupt and enforced end. The public was greatly enraged and indignant.

The incidents already mentioned are truly amazing, yet there are other intriguing curiosities about the monument. It is built, "upside down and inside out"; it "breathes"; it has "tuberculosis"; and it produces its own "rain".

In 1911, Mr. G. P. Merrill, head curator of geology at the National Museum, made the first above-mentioned charge, saying:-

"The very best and most enduring material lies in the inner courses of the upper portion - which bears the least strain. The poorest and weakest material is compressed in the outer portion of the first 190 feet, which has to bear the weight of the rest - and receives the wash from all the rain that falls on the portion above."

Representatives of the U. S. Army Corps of Engineers reported that it had a regular pulsation, popularly described as "breathing", and a lateral contraction and expansion which necessitated the use of channel irons to support the stairway. This is a natural phenomenon, however, and in no way endangers the monument.

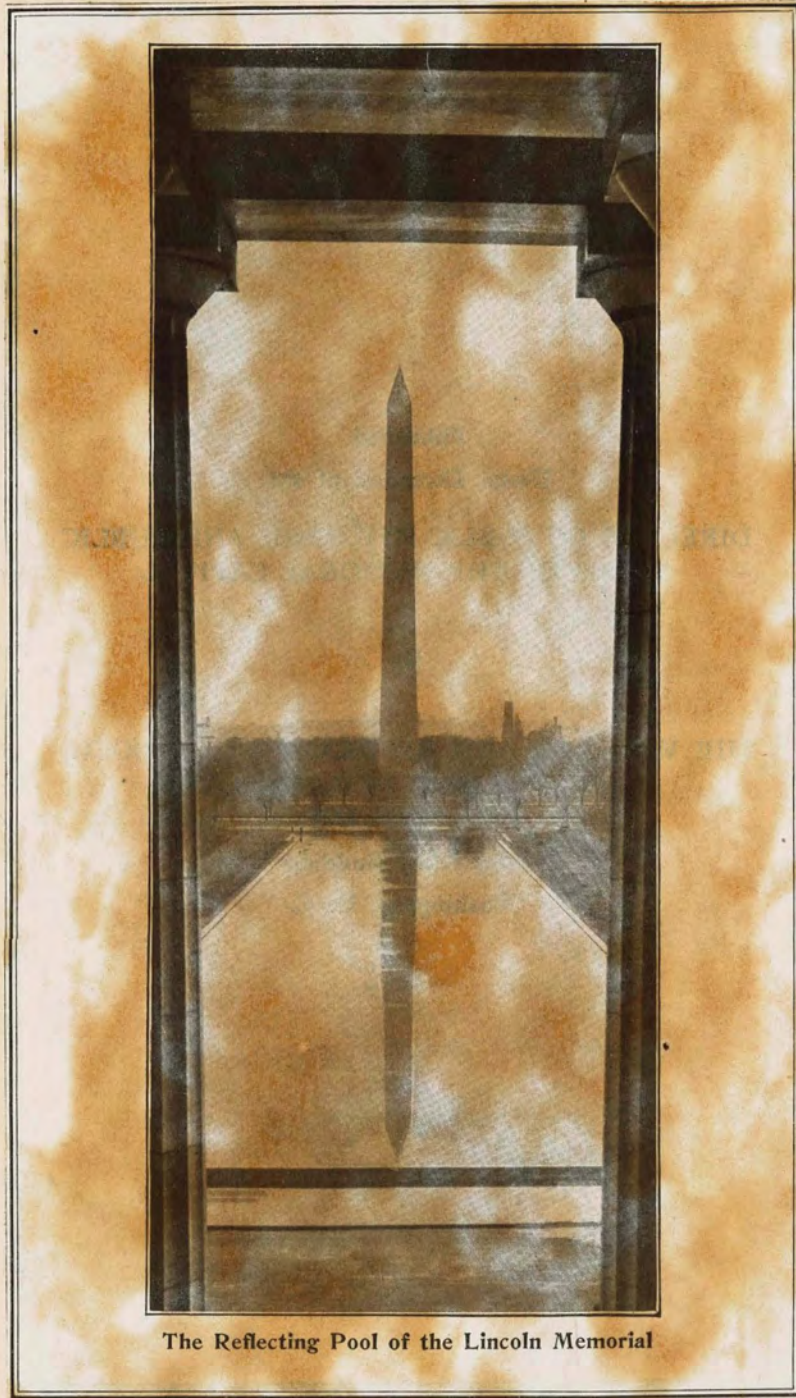
Exudations of the rubble masonry through interstices in the stone gave rise to the facetious claim that the monument suffered from "geological tuberculosis". The disintegration has been stopped by drilling through the inner walls and forcing in new cement under hydraulic pressure.

Because of the relatively slow response of the walls to outside temperature changes, a sudden warm spell following cold will cause a condensation of moisture in the air within the shaft until actual precipitation occurs. This "rain" sometimes necessitates overshoes and raincoats inside while the sun may be shining brightly without.

There is enough room in the interior of the monument to house an army of approximately 12,000 men. 7,675 on the landings; 3,845 on the stairs; 450 on the upper and lower platforms, and 30 in the elevator would fill the monument to capacity.

Senator Sherman:-

"The monument speaks for itself, - simple in form, admirable in proportions, composed of enduring marble and granite, resting upon foundations broad and deep, it rises to the skies higher than any work of human art. It is the most imposing, costly, and appropriate monument ever erected in the honor of one man."



The Reflecting Pool of the Lincoln Memorial

The Monument Seen From the Reflecting Pool of the
Lincoln Memorial.

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